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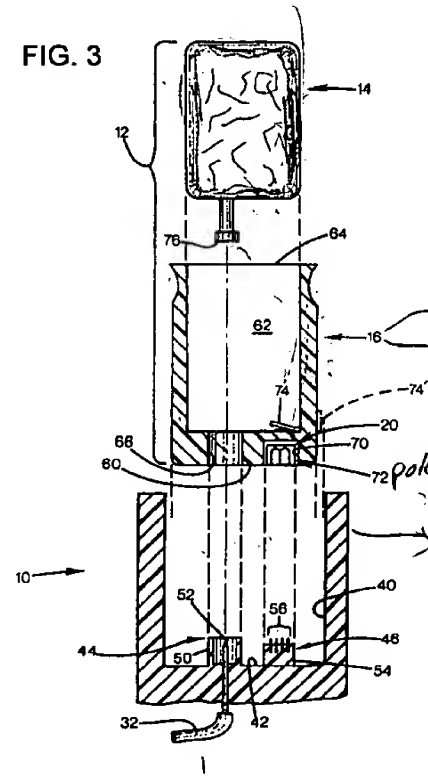
(54) Ink jet cartridge with separately replaceable ink reservoir

(57) A replaceable ink cartridge (12) for an ink jet printer (10) having an ink supply station (40) with an ink receptacle (44) and an electric connector (46). The cartridge includes a chassis (16) removable from the ink supply station, and having an ink passage (66) and an electrical connector (72) connectable to the printer's electric connector. An ink reservoir (14) is removably connected to the chassis, and has a chamber containing a supply of ink. The reservoir has an ink outlet (76) registered with the ink passage, and the chassis has an ink level annunciator (20) connected to the cartridge's electrical connector, for generating a signal to enable printing after the ink reservoir is depleted and replaced with a second reservoir.

FIG. 3



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Description

Field of the Invention

This invention relates to ink jet cartridges, and more particularly to two-part ink jet cartridges with separate ink supplies.

Background and Summary of the Invention

A typical ink jet printer has a pen that reciprocates over a printable surface such as a sheet of paper. The pen includes a print head having an array of numerous orifices through which droplets of ink may be expelled into the surface to generate a desired pattern. Some ink jet printers have a replaceable ink supply mounted to a stationary position on the printer, and connected to a reciprocating print head by a conduit. This permits the use of a larger ink supply, and avoids the need to replace the print head each time the supply of ink is depleted. Color ink jet printers generally have a multi-chamber cartridge, or several ink supply cartridges each containing a different color of ink.

Some existing systems provide each stationary ink supply cartridge with an on board electronics memory chip to communicate information about the contents of the cartridge. It may also be possible for such a chip to serve as a "gas gauge" that indicates or transmits to the printer the amount of ink remaining, so that the printer does not continue printing with an empty cartridge.

The on board memory in an ink cartridge may also serve to record or store other information about the ink cartridge, such as manufacture date (to ensure that excessively old ink does not damage the print head,) ink color (to prevent misinstallation,) and product identifying codes (to ensure that incompatible or inferior source ink does not enter and damage other printer parts.)

However, for very low cost applications, these advantages provided by a memory chip in each disposable cartridge may be outweighed by the cost of replacing the chip every time a cartridge is depleted. In addition, there may be other elements in a cartridge, such as structural, plumbing, and pumping components, that have useful lives that extend well beyond the time it takes to deplete the ink supply. Yet even with separate chips and ink supply elements, simply replacing or refilling the ink supply portion of an existing cartridge will not enable its operation, as the existing memory chip may continue to indicate a depleted or beyond-shelf-life cartridge, causing the printer to refuse to proceed to avoid risk of damage or faulty output. Therefore, there is a need for a low cost ink jet printing system that permits retaining non-depleted elements of an ink cartridge while restoring an ink supply, for a printer that has sensors to avoid using a depleted or dated cartridge.

The present invention overcomes or reduces the disadvantages of the prior art by providing a replaceable ink cartridge for an ink jet printer having an ink supply station with an ink receptacle and an electrical connector. The cartridge includes a chassis removable from the ink supply station, and having an ink passage and an electrical connector connectable to the printer's electrical connector. An ink reservoir is removably connected to the chassis, and has a chamber containing a supply of ink. The reservoir has an ink outlet registered with the ink passage, and the chassis has an ink level annunciator connected to the cartridge's electrical connector, for generating a signal to enable printing after the ink reservoir is depleted and replaced with a second reservoir.

Brief Description of the Drawings

Figure 1 is a perspective view of a printer according to a preferred embodiment of the invention.

Figure 2 is a simplified block diagram of the embodiment of Figure 1.

Figure 3 is a simplified, exploded sectional view of the embodiment of Figure 1.

Figure 4 is a flow chart illustrating a method of operation of the embodiment of Figure 1

Figure 5 is a flow chart illustrating an alternative method of operation of the embodiment of Figure 1.

Detailed Description of a Preferred Embodiment

Figures 1 and 2 shows an ink jet printing system 10 having a removable ink cartridge 12 for printing onto a sheet of media 13. The ink cartridge includes an ink reservoir 14 defining a chamber filled with ink, and a chassis 16 that includes a cartridge memory chip 20. The printer has a housing 22 enclosing a controller 24 connected to the cartridge chip 20 via four electrical lines 26. An ink level display 30 is mounted to the housing and electrically connected to the controller as shown, or may be displayed on the user's video display terminal by computer software. A print head 32 having a memory 33 and a print element 34 reciprocates within the housing adjacent to the sheet of media. An ink tube 35 connects the ink supply to the print head, providing ink for printing. A print head control bus 36 electrically connects the controller to the print head, and transmits printing data to the print head. While the schematic is shown as having a single print head and a single ink cartridge for simplicity, the preferred embodiment has four of each element, each corresponding to a particular ink color (black, cyan, yellow, and magenta.) A computer 37 connected to the printer 10 includes a printer driver 38 connected to the controller 24, a central processing unit 39, and a connected monitor 41.

Figure 3 shows how the components 14, 16 of the ink cartridge 12 are removably connectable to the printer 10. The printer defines an ink supply station cavity 40 that is fixed relative to the printer housing, and which provides a receptacle to entirely receive the ink cartridge. The station cavity has a floor 42 upon which

are mounted a fluid interconnect 44 and an electrical interconnect 46. The fluid interconnect includes an alignment sleeve 50 surrounding a hollow needle 52, with the needle defining a passage connecting to the ink tube 35. Although not shown in detail, the needle is provided with an enclosure to maintain humidity when an ink cartridge is not installed.

The electrical interconnect includes a protruding boss 54 having four pins 56 formed to present laterally extending bent portions. The fluid and electrical interconnects are spaced apart from each other to prevent unexpected ink leakage from encountering the electrical elements.

The chassis portion 16 of the ink cartridge is a rigid rectangular shell having a flat, planar aspect parallel to the plane of the figure. The chassis has a leading edge 60 extending toward the floor 42 of the cavity. The chassis is largely hollow, as it defines a reservoir chamber 62 that is open on a trailing edge 64 of the chamber. An ink passage 66 provides an opening from the reservoir chamber 62 through the leading edge 60, in registration with the alignment sleeve 50 for mating therewith. A pocket 70 is defined in the leading edge of the chassis at a position spaced apart from the ink passage 66. A connector 72 having four separate, conductive planar conductors is mounted to one wall of the pocket, so that is parallel to the plane of the ink cartridge. This permits the printer's interconnect pins to scrape along the respective pads as the cartridge is inserted into the ink supply station cavity 40, removing any oxidation or contamination from the pads to ensure proper ohmic contact. The chassis includes a memory chip integral with or beneath the connector and having connections to each of the four connector pads.

A leaf spring reset switch 74 within the chamber 62 is also connected to the memory element for sending a signal to the memory element when a reservoir is reseated in the chamber, closing the switch. An alternative reset switch 74' may be mounted to the exterior of the chassis for manual actuation by a user upon replacement of an ink reservoir.

The ink reservoir 14 is a planar body defining an ink chamber. Preferably, the bag has sufficient flexibility to permit it to collapse to a thin, planar condition as its contents are depleted. Alternatively, it may have a thin, rigid shell to permit it to be readily inserted into and removed from the chassis chamber 62, with a collapsible bag inside, or with valved vents that permit pressure equalization with the outside atmosphere as ink is consumed. At the leading edge of the reservoir, an ink outlet 76 protrudes from a position in registration with the ink passage 66 of the chassis and with the needle 52 of the fluid connection 44. The ink outlet has an end face sealed by a self-sealing septum that may be penetrated by the needle. The exterior of the outlet is shaped to be closely received within and supported by the ink passage 66 to provide registration during installation of the entire cartridge in the printer.

The printer controller 24 is programmed to keep track of printing activities to maintain an estimate of how much ink has been consumed from each cartridge Essentially, this may be thought of as a drop counter. Normally, the memory chip on the cartridge chassis serves as the storage site for the drop usage information. The memory of the chip may begin with an "ink full" condition value, which is decremented as printing proceeds, until an "ink empty" state is reached, whereupon the printer will not function until the cartridge is replaced with one indicating "ink fill" or an intermediate condition.

By storing this information on each cartridge, cartridges may be removed and replaced without losing usage information. As printing proceeds, the printer reads the usage information stored on the cartridge memory, and displays a corresponding output on the display 30, which may be in the form of a bar graph or "gas gauge." Unlike a fuel gauge in an automobile, such a gauge does not need to sense the current fluid level in the reservoir, so that complicated ink level sensors are not needed.

In the preferred embodiment, the memory chip is an EEPROM that may be written to or decremented as ink usage proceeds. Upon complete depletion, the chip must be reset, either by release and reactuation of the leaf spring switch 74 when a reservoir is replaced, or by manual actuation of switch 74'. In the preferred embodiment, the chip and connector have four lines: power, ground, clock, and input/output. The chip may be an MROM that is never written to, or may include a combination of MROM, EPROM, and EEPROM portions, to emulate the performance of a standard chip. In one embodiment, the drop counter may have an 8-bit write-once memory location, with each bit corresponding to one-eighth of the ink supply, and written to after a fine counter tallies a usage of a quantity of ink droplets equivalent to one-eighth the cartridge capacity.

Each cartridge memory chip may include factory-recorded information such as cartridge volume, day of manufacture, year of manufacture, freshness/expiration date, ink shelf life, and product serial number. The memory may also include ink chemistry and colorimetry data, and information on ink drying time and outgassing rate to enable optimized printing during the life of the cartridge. The chip is also occasionally written to by the printer in conjunction with usage. Such information may include a coarse usage indication in eighths of the total volume, a fine drop count, first usage date, most recent usage date, and duration of time in use.

The preferred method of operation is shown in Fig. 4. Before printing, the printer is turned on, and the driver and firmware of the printer read the ink level or drop volume from each cartridge memory chip. If a cartridge is absent, the printer will not print, and the user may be notified of the need to install a cartridge. Each time a different cartridge is installed, the contents of the cartridge memory are read into a memory a cache associated with the printer controller.

Operation begins with installation 110 of the chassis and the reservoir, which have previously been connected to each other. The user then initiates a new print job 112, causing the printer to query 114 the cartridge memory chip to determine the amount of ink in the reservoir. The controller calculates an ink level based on the received data, and sends a signal to the display to indicate 116 the ink level to the user. The controller assesses 118 whether the ink supply is empty.

If the ink supply is not empty, the printer prints 120 a portion of the printing job, and updates 122 the memory chip to reflect the ink usage during that printing step. This may include writing to a fine counter on the cartridge memory, and if the fine counter becomes full, writing to one of the coarse counter bits and resetting the fine counter to zero for subsequent printing. The printer then determines 124 whether the print job is complete. If so, the printer stops and awaits 126 instructions to begin a new printing job, whereupon the printer proceeds to step 112 to start the new job. During the print job, at the end of printing each sheet in the job, the controller will read all memory elements to update the displays reflecting ink supplies. This will permit user monitoring of ink consumption during large print jobs.

If step 118 determines that the ink supply is empty, the printer halts 128 the print job, and indicates on the display that the ink is empty. To proceed, the user must replace 130 the ink reservoir. Preferably, this involves removing the entire ink cartridge, then removing the depleted reservoir from the chassis and replacing it with a full reservoir. If the chassis lacks a leaf spring-type reset switch to provide a reset signal 132, the user manually actuates the reset button. Then, the entire cartridge is installed in the ink supply station, so that the needle penetrates the septum to provide ink flow, and so that the electrical connector makes contact with each of the four pads on the connector. In an alternative method, the user may retain the depleted ink reservoir, and refill it with ink by injecting ink from a hypodermic needle or other source.

Resetting the memory chip causes the chip to erase ink depletion data or, alternatively, to rewrite data reflecting remaining ink quantity. In either event, the memory is returned to a condition equivalent to an "ink full" condition, so that printing may proceed, and ink volume remaining may be properly displayed and updated during subsequent printing. Resetting may be achieved either by changing the coarse count and/or the fine count, and by changing the other recorded data relating to manufacture, expiration, and usage dates.

After the cartridge is replaced, the printing job is restarted 134.

An alternative printing operation is shown in Fig. 5. In this embodiment, the ink cartridge may have a simpler ROM chip instead of the EEPROM. The chip is programmed to constantly provide an "ink full" signal to the printer, preventing the printer from shutting down due to depleted ink. Thus, when the printer checks the chip for ink supply level, it reads the "all full" signal, and proceeds to print 220 the entire job, or portions of the job after occasionally rechecking the ink level. In this embodiment, the printer will proceed until the ink supply runs dry, so the user may occasionally determine 222 whether there is ink in the reservoir, typically by ensuring that printed pages are being output properly. If the ink supply is empty 224, the user may replace 226 or refill the ink supply, and start a new print job. If the supply is not empty, printing may proceed without replacement.

In a variation on the Fig. 5 embodiment, a printer may have a less sophisticated level detection process that only senses whether the cartridge is empty or not, without determining the current level for display. In such a system, the printer may print as long as one of the chip outputs is maintained at a given voltage level, and will stop printing when the output voltages changes to a different level. For such an application, the chip may be eliminated from the cartridge chassis, and the output pad of the connector hardwired, either to the ground or voltage input to provide a continual signal corresponding to "ink full." Thus, the printer will attempt to write the droplet usage information to decrement a counter, but the output voltage will remain unchanged.

In alternatives to the Fig. 4 embodiment, the chip may have additional circuitry to automatically reset the ink level whenever the counter reaches empty, or the user may cause such a reset by connecting the chassis to a separate reprogramming box (not shown) that generates the appropriate reprogramming signal.

Also, to avoid triggering the shut down of a printer programmed to read a date code on the chip to avoid printing with ink beyond it's useful shelf life, the reset operation in all embodiments may also trigger a date reset in the chip.

In some printers programmed to a very high level of selectivity of cartridge acceptance, error circuitry may be provided to verify that the chip in an inserted cartridge is not defective. This may use techniques of attempting to read, write, and/or erase various sectors of the chip's memory, and read to ensure that each sector responded as expected. For such a printer, the cartridge memory chip will have emulation capability to emulate the needed functions, while retaining the ability to reset the ink level state as needed.

In another alternative embodiment, a kit may be provided that includes a single chassis and multiple ink reservoirs, or a single chassis and reservoir and a refill bottle for refilling the reservoir. In either embodiment, the operation may proceed as above, or may use a chip programmed to indicate an initial ink volume equal to the volume of all reservoirs in the kit of the entire refill bottle contents. Thus, the ink level indicator would not inform when a single reservoir required replacement or refill, but would indicate when the entire kit was reaching depletion.

While the invention is described in terms of pre-

ferred and alternative embodiment, the following claims are not intended to be so limited.

Claims

1. A replaceable ink cartridge (12) for an ink jet printing system (10) having an ink supply station (40) with an ink receptacle (44) and a printer electrical connector (46), the cartridge comprising:

   a chassis (16) removably matable with the ink supply station, the chassis defining an ink passage (66) and including a cartridge electrical connector (72) matable with the printer electrical connector;
   an ink reservoir (14) defining a chamber containing a supply of ink of a selected volume;
   the reservoir having an ink outlet (76) registered with the ink passage; and
   the chassis having an ink level annunciator (20) connected to the cartridge electrical connector and operable to generate a signal to enable printing after a total volume of ink greater than the first volume, such as when the ink reservoir is depleted and replaced with a second reservoir, refilled, or connected to an additional reservoir.

2. A replaceable ink cartridge according to claim 1 including a reset switch (74) connected to the annunciator and wherein the annunciator is operable in response to activation of the reset switch to generate a signal indicating that the cartridge is full of ink.

3. A replaceable ink cartridge according to claim 1 or claim 2 wherein the annunciator (20) is operable to generate an "ink full" signal regardless of ink level.

4. A replaceable ink cartridge according to any one of claims 1 to 3 wherein the chassis defines a chamber (62) receiving at least a portion of the reservoir.

5. A replaceable ink cartridge according to any one of claims 1 to 4 wherein the chassis and the reservoir together comprise a flat, rectangular body defining a major plane, and wherein the ink passage and the electrical connector are located along a common edge (60) of the body, and spaced apart from each other.

6. A replaceable ink cartridge according to any one of claims 1 to 5 wherein the ink reservoir (14) is removably connected to the chassis (16), such that it may be replaced upon depletion without requiring replacement of the chassis.

7. A method of servicing an ink jet cartridge (12) removable from a printer (10) operable in response to an ink level signal from the cartridge, the method comprising:

   removing the cartridge from the printer (130);
   replenishing the cartridge with ink;
   installing the cartridge into the printer; and
   generating an ink level signal to permit operation of the printer (132).

8. A method of servicing an ink jet cartridge according to claim 7 wherein generating an ink level signal (132) comprises generating an "ink full" signal independent of the amount of ink in the reservoir.

9. A method of servicing an ink jet cartridge according to claim 7 or claim 8 wherein generating an ink level signal comprises continuously generating an "ink full" signal (114).

10. A method of servicing an ink jet cartridge according to any one of claims 7 to 9 including resetting an ink level switch (132) on the chassis.

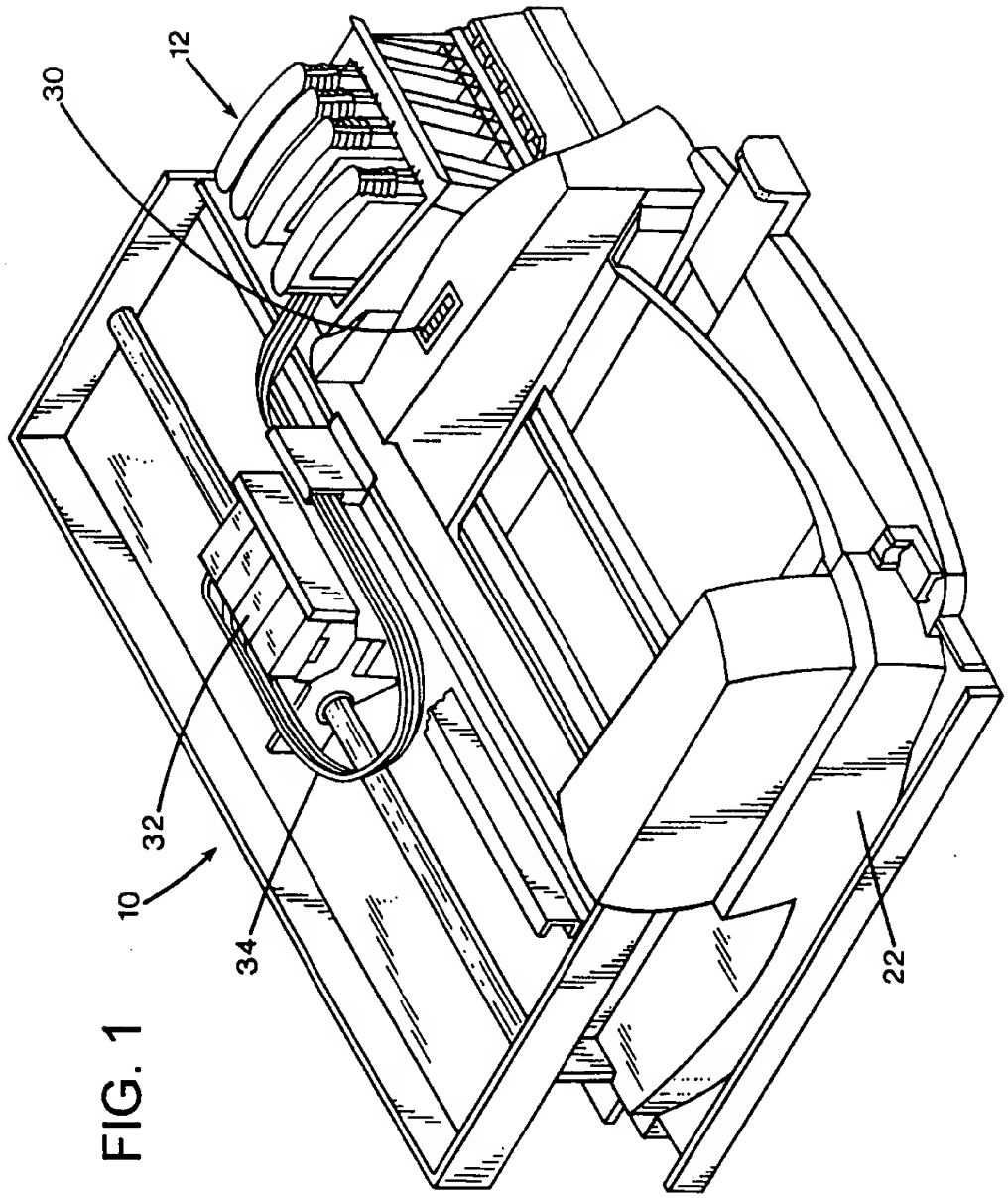


FIG. 1

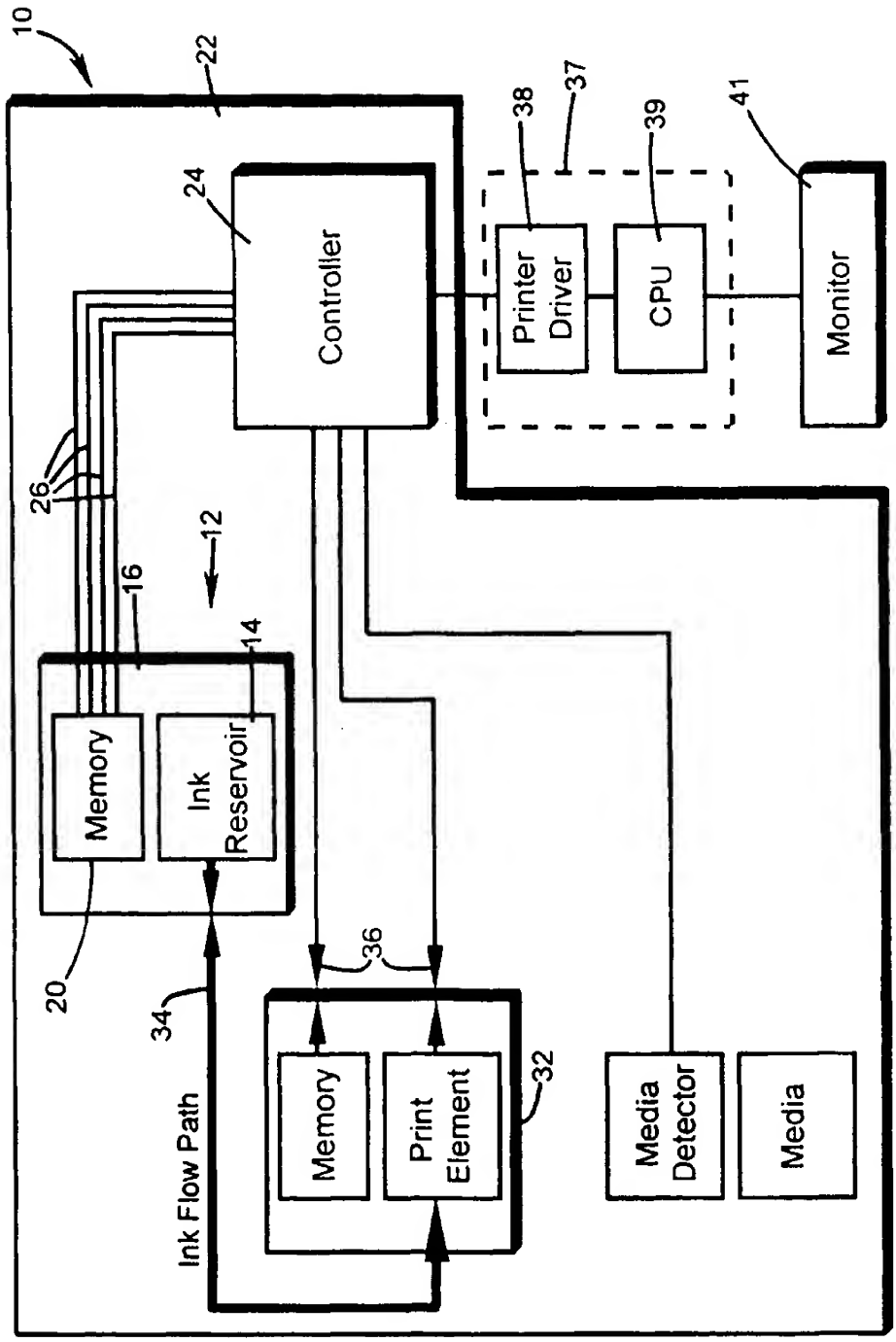

10
22
24
Controller
38
37
39
41
Printer Driver
CPU
Monitor
26
12
16
14
Memory
Ink Reservoir
20
34
36
32
Memory
Print Element
Ink Flow Path
Media Detector
Media

FIG. 2

FIG. 3

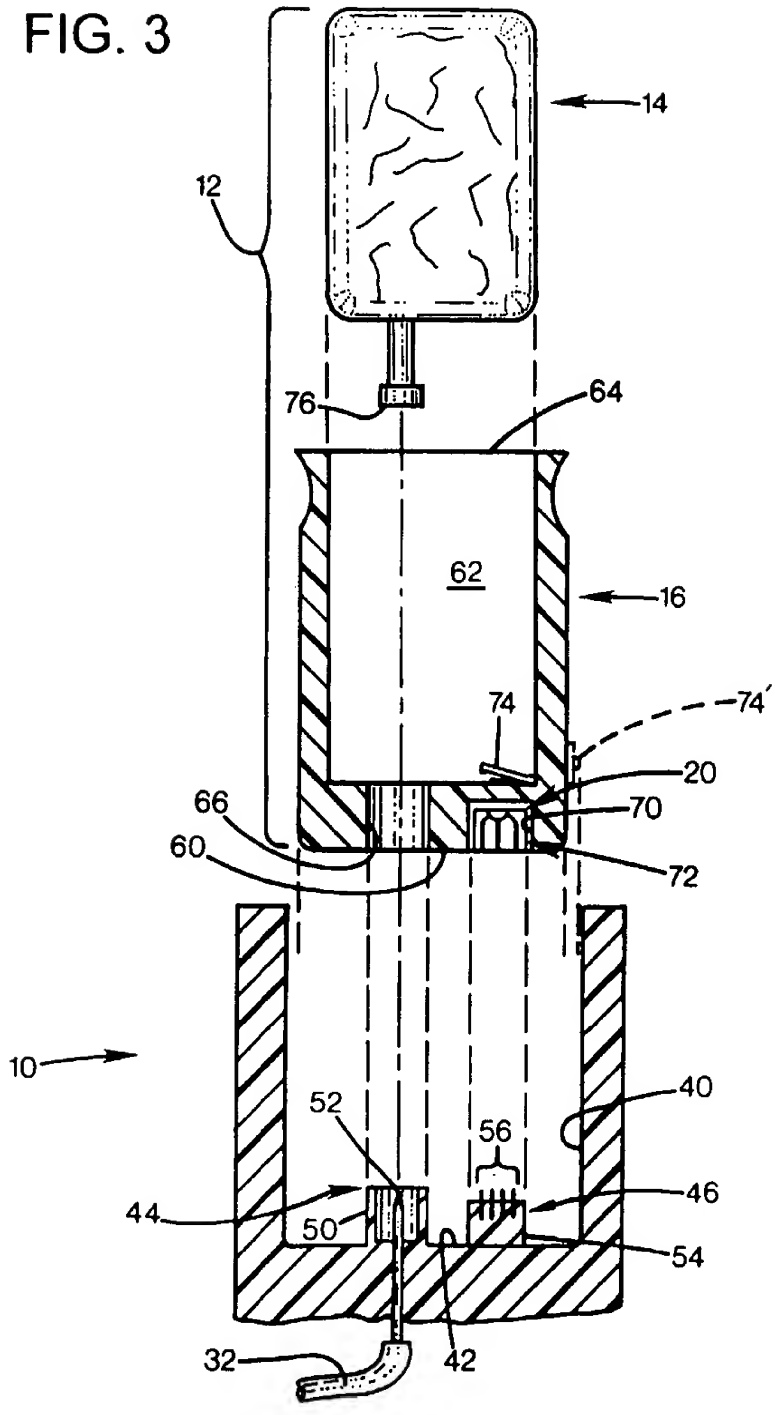
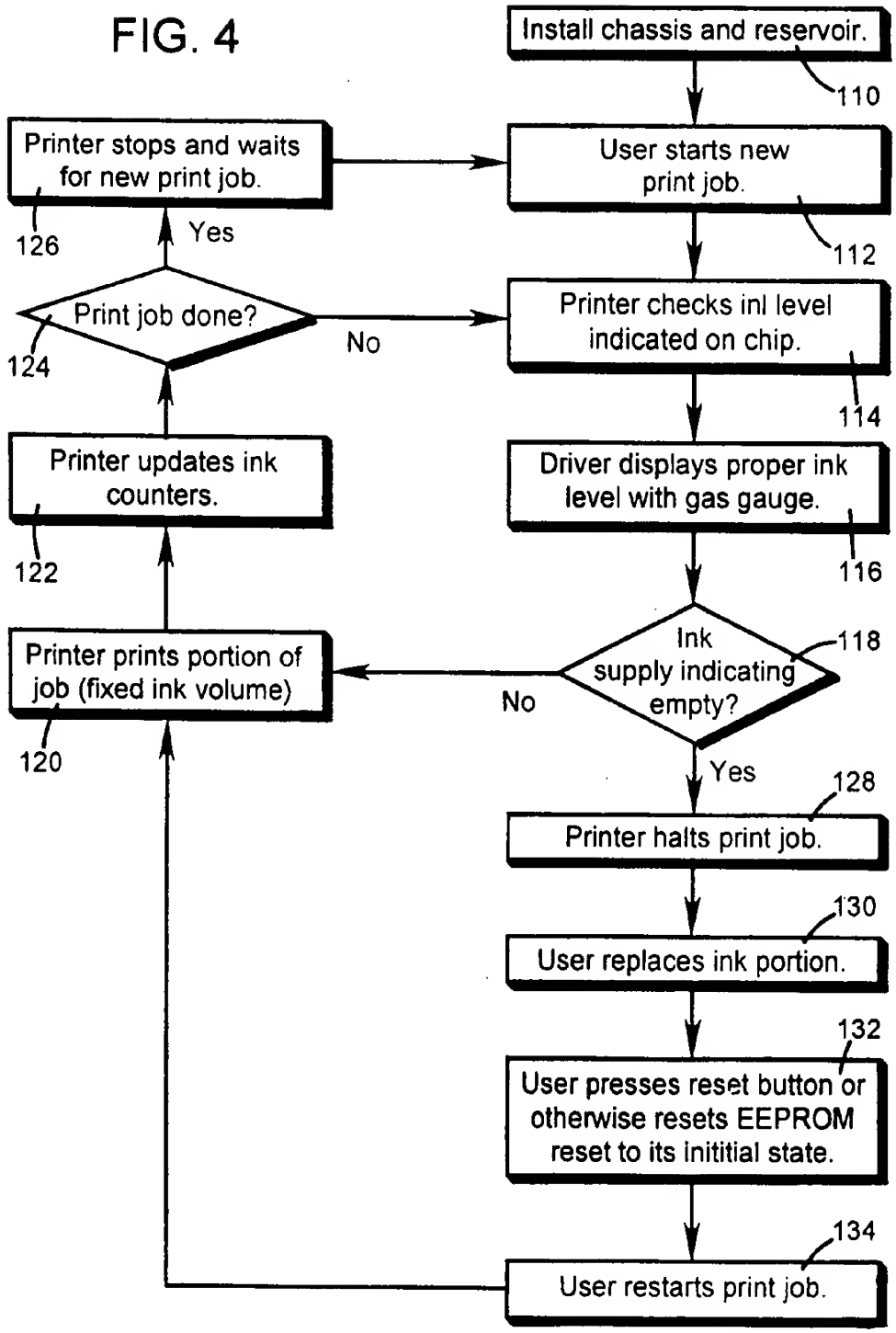


FIG. 4


Install chassis and reservoir.
110
User starts new print job.
112
Printer checks inl level indicated on chip.
114
Driver displays proper ink level with gas gauge.
116
Ink supply indicating empty?
118
No
Yes
Printer prints portion of job (fixed ink volume)
120
Printer updates ink counters.
122
Print job done?
124
No
Yes
Printer stops and waits for new print job.
126
128
Printer halts print job.
130
User replaces ink portion.
132
User presses reset button or otherwise resets EEPROM reset to its inititial state.
134
User restarts print job.

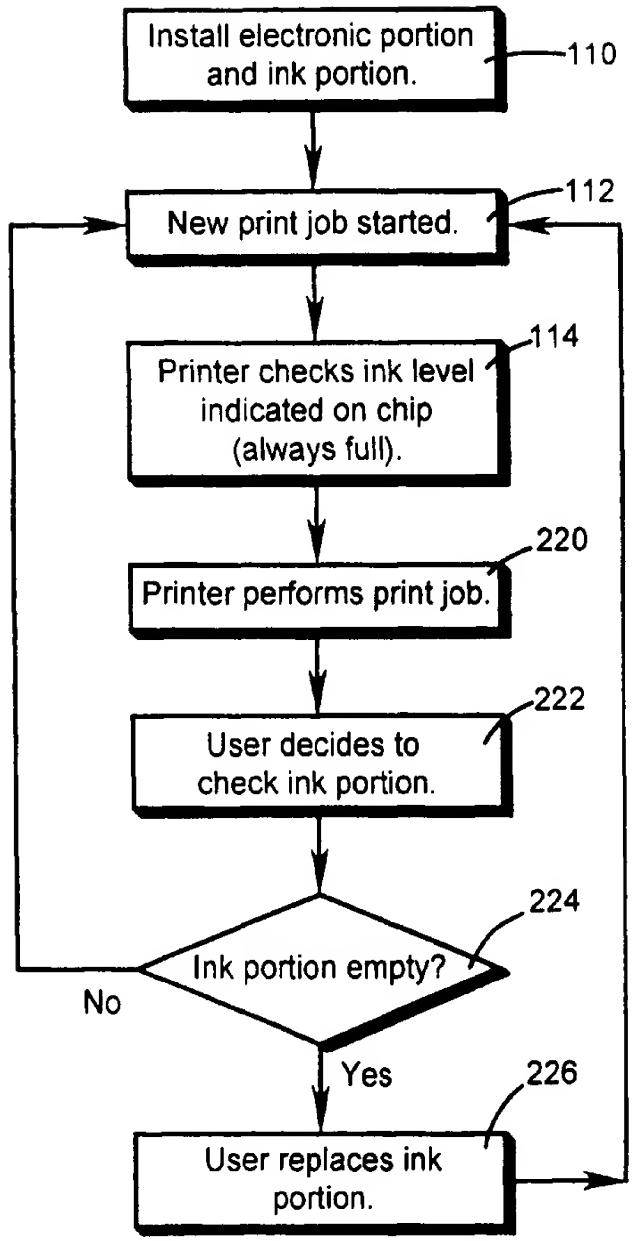

Install electronic portion and ink portion.
110
New print job started.
112
Printer checks ink level indicated on chip (always full).
114
Printer performs print job.
220
User decides to check ink portion.
222
Ink portion empty?
224
No
Yes
User replaces ink portion.
226

FIG. 5